Plankton

Bio-Science Series

Top view of *Porpalia* (cover), a colonial zooplankter.

Booklet-cover photograph by Oxford Scientific Films

Order additional teachers guides from National Geographic Society, 17th and M Streets N.W., Washington, D. C. 20036; $1.25 for one guide, $1.00 per guide for 15 guides or more.

Bio-Science Series, Plankton © 1976 National Geographic Society, 17th and M Streets N.W., Washington, D. C. 20036. All rights reserved. Reproduction of the whole or any part of the contents without written permission is prohibited.

Synopsis

Plankton gives the viewer an underwater look at the mysterious varieties of plants and animals that make up the ocean's teeming mass of "plankton soup." These drifting organisms, many of them invisible to the naked eye, comprise the essential link in the ocean's food chains. Without them, our oceans would be virtually lifeless.

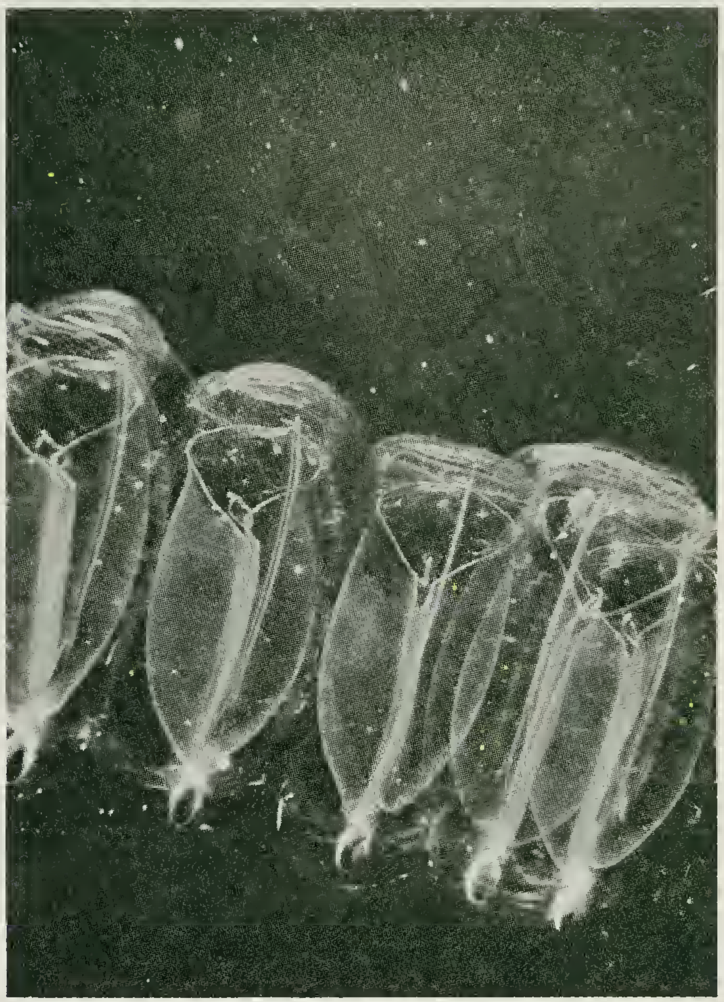
Drifting plants (**phytoplankton**) are the most abundant forms of plankton. These fantastic miniature chemical factories use energy from the sun to transform inorganic material into life-supporting substances, which are stored in their tissues. Such plants, directly or indirectly, support most marine animal life.

Planktonic animals (**zooplankton**) consume planktonic plants. These animals, such as radiolarians, pteropods, and copepods, are in turn food for the larger creatures in the ocean. You'll see the *Amphinema* jellyfish, also a planktonic animal, capture and digest the larva of a marine worm. Most zooplankton sink into the darkness of the ocean by day and migrate toward the surface at night, a behavioral phenomenon still under study.

Some zooplankton are actually the larvae of large, familiar sea animals. Because the larval forms of such animals are so different from their adult forms, many were once thought to be separate, unrelated species. In the film you will watch the minute larvae of crabs and barnacles develop into their adult forms.

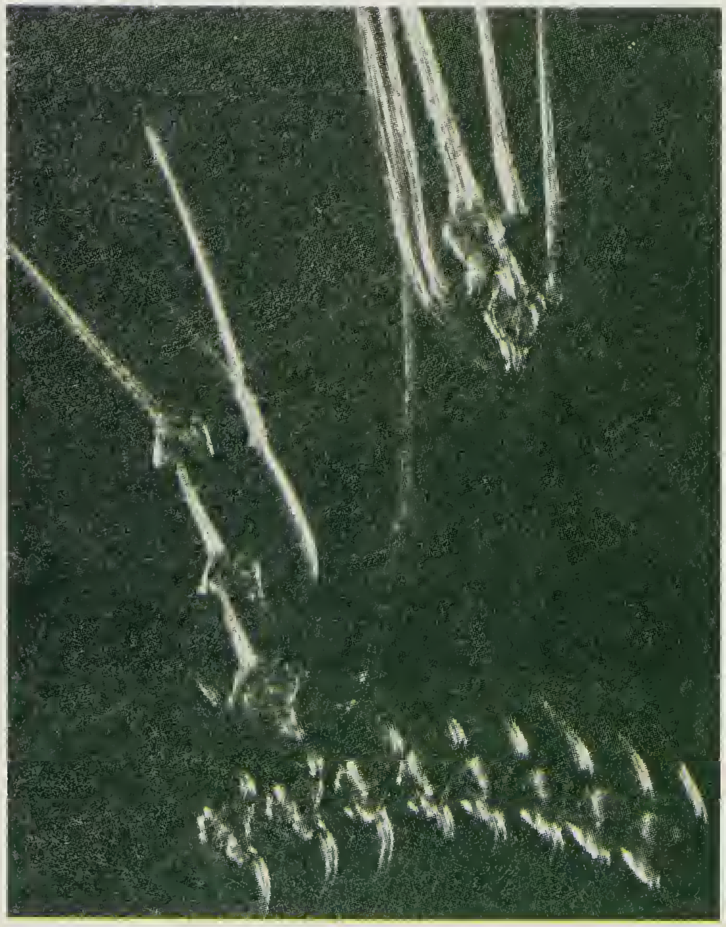
Plankton, diverse in size and shape and vital to all that lives in or comes from the earth's vast seas, are continuing mysteries to the scientists who study them.

L. P. Madin



Salps, like this *Pegea,* are a form of zooplankton. Generations of salps alternate between solitary individuals and individuals that are linked together. Each *Pegea,* about two inches high, forces water through its body and traps food in a net of mucus.

Paul A. Zahl



Each of these three-pronged organisms is a dinoflagellate, a type of plankton.

To the Teacher

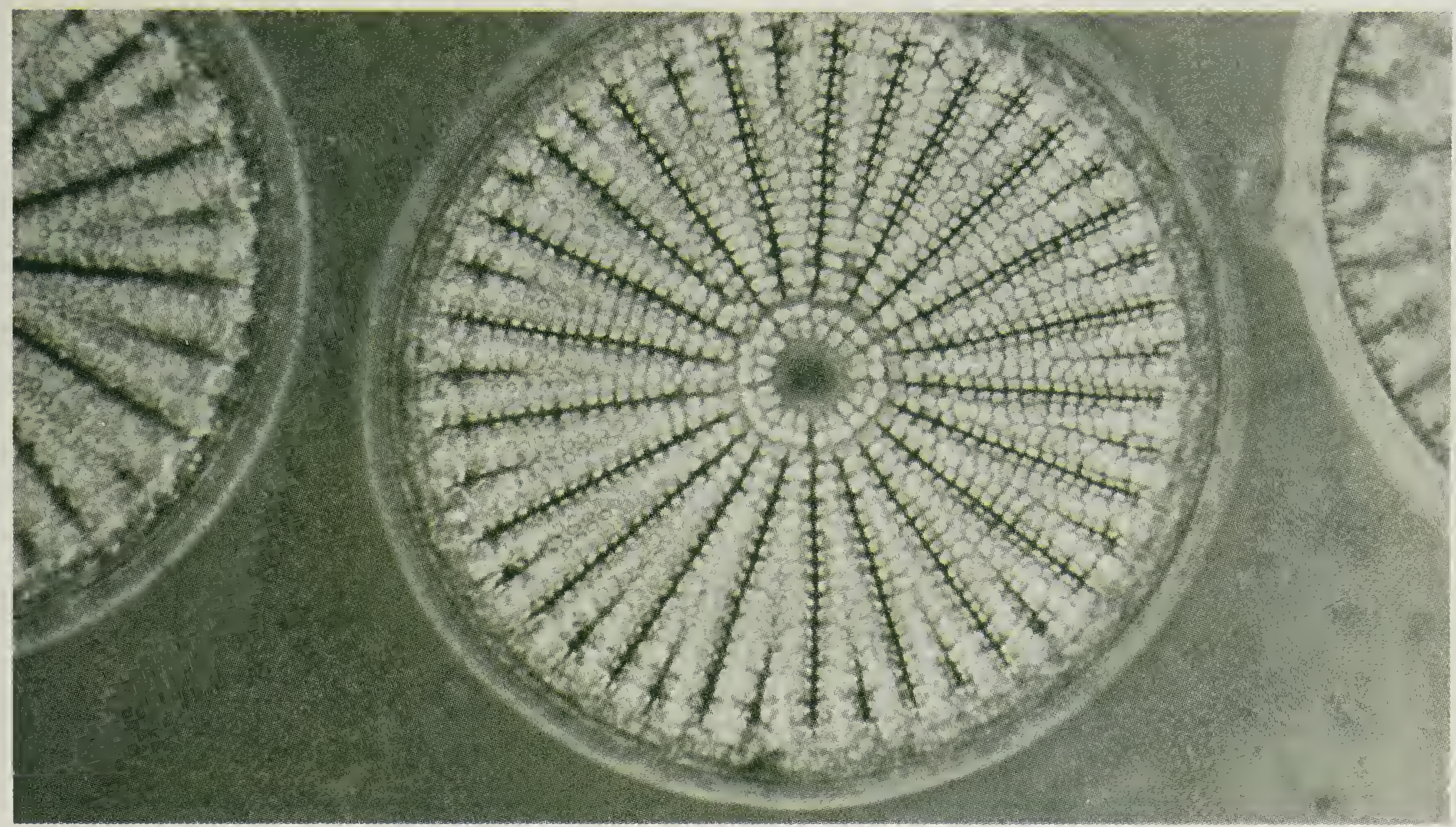
This Teachers Guide is designed to aid you in preparing for your classes. If time permits, we suggest that you first preview the film, familiarizing yourself with the footage and the major themes of the narration. Next, carefully read through this guide. The Key Points were developed to elaborate on concepts presented in the film and to supply additional information to you and your students. We encourage you to photocopy any sections of this guide that will help your students better understand plankton. The activities suggested in this booklet were chosen because they are simple, enjoyable, and closely related to the themes already mentioned in the film and the Key Points. A section listing lab suppliers and reference materials is included to assist you in making the broadest possible use of the film in your classes.

Objectives

After viewing the film, discussing the Key Points, and participating in the activities suggested in this guide, the student will be able:

☐ to define "plankton," and cite examples of phytoplankton and zooplankton;
☐ to describe an ocean food chain, charting some of its interdependent relationships;
☐ to outline the seasonal and daily cycles of marine plankton, noting the sun's influence on each; and
☐ to summarize the developmental stages of temporary plankton.

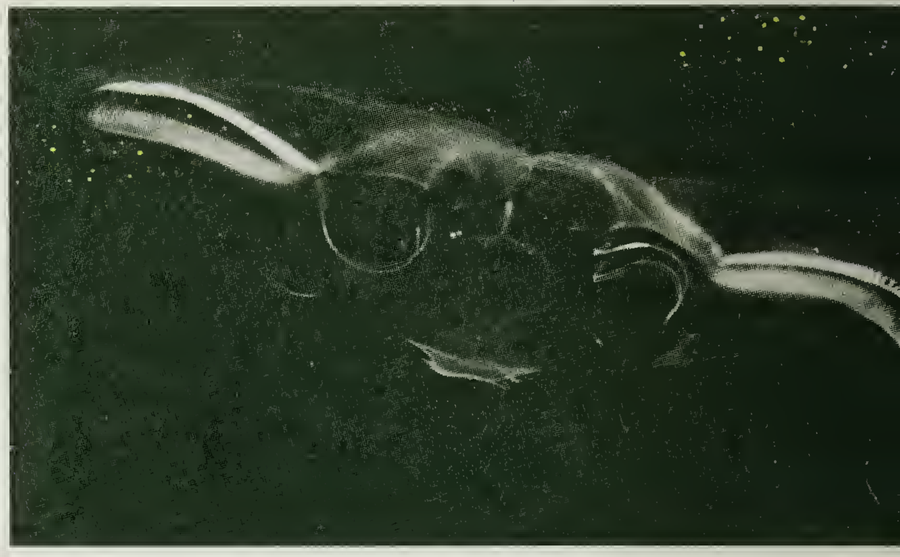
Paul A. Zahl



The silica skeleton of a diatom.

Key Points

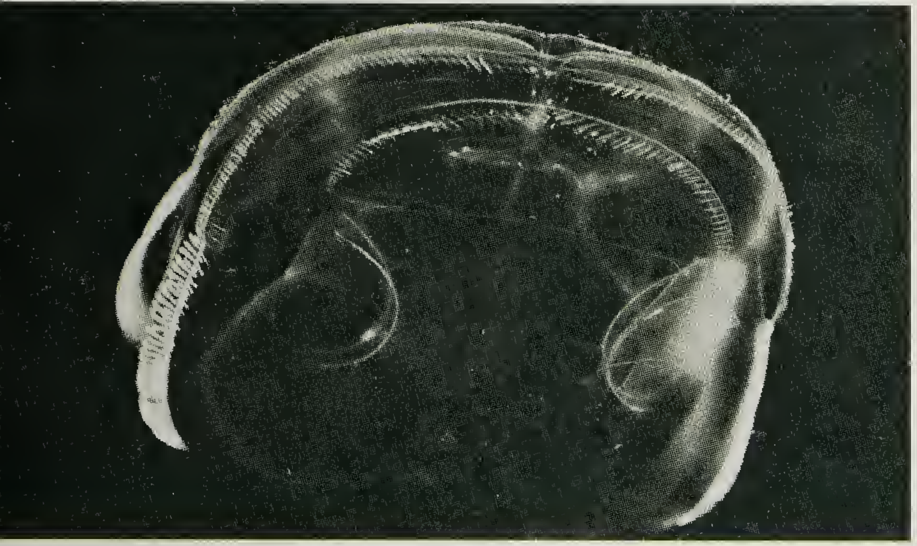
What is plankton?: Marine plankton comprise a vast, diverse community of organisms ranging in size from microscopic plants to large jellyfish. These floating plants and animals abound in the world's oceans. In fact, if you've ever swallowed some seawater while swimming, you've probably snacked on some harmless and highly nutritious plankton. The word ''plankton'' means ''that which drifts,'' and although some forms of plankton seem to be very active swimmers, in fact, all drift at the mercy of ocean currents.

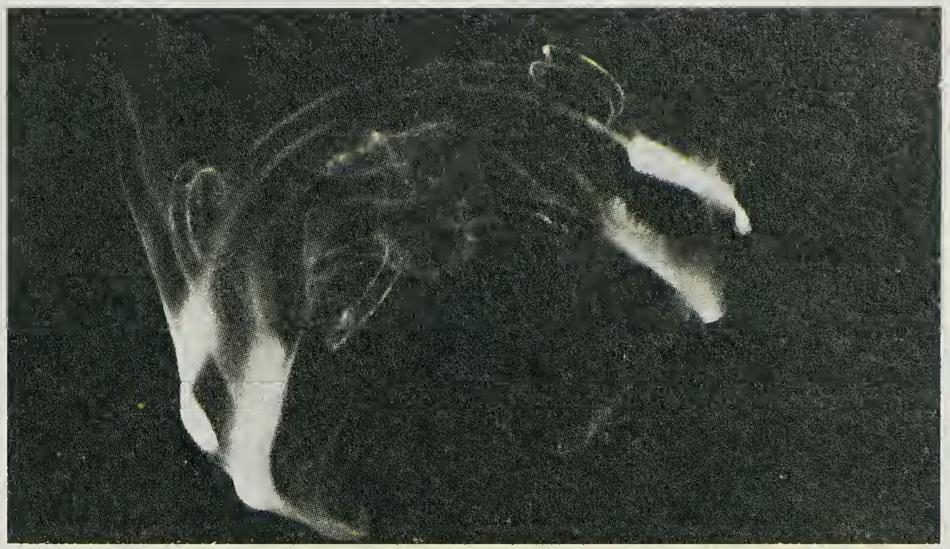


The energetic zooplankter *Ocyropsis maculata* moves through the water in pulsating motions. First it spreads its three-inch "wings" (left) then flaps them down to thrust itself forward (middle). *Ocyropsis* unfolds its "wings" again for the next stroke (right).

Phytoplankton are often referred to as "the pasture of the sea." They are the primary food producers of the sea, the base of the ocean's food chains, upon which all marine animal life directly or indirectly depends. Our ocean surfaces teem with these drifting plants. Far more abundant than plants on land, phytoplankton, like their terrestrial cousins, are dependent on the sun for carrying on photosynthesis, and therefore live near the ocean surface. Each plant **plankter** (a single planktonic organism) is capable of using the sun's energy to transform inorganic material into the carbohydrates, fats, and proteins necessary to support marine animal life.

In ocean waters diatoms are the most numerous phytoplankton. More than 5,000 species of these cool-water plants inhabit the earth's seas. Diatoms provide zooplankton and small fish with a hearty daily diet. Their virtually indestructible silica skeletons fall and accumulate on the ocean floor. The fossilized remains of these plankton are often mined by man and used in the manufacture of toothpaste, metal polish, and insulation. Geologists suspect that the world's supply of oil was created by the breakdown of diatom protoplasm.





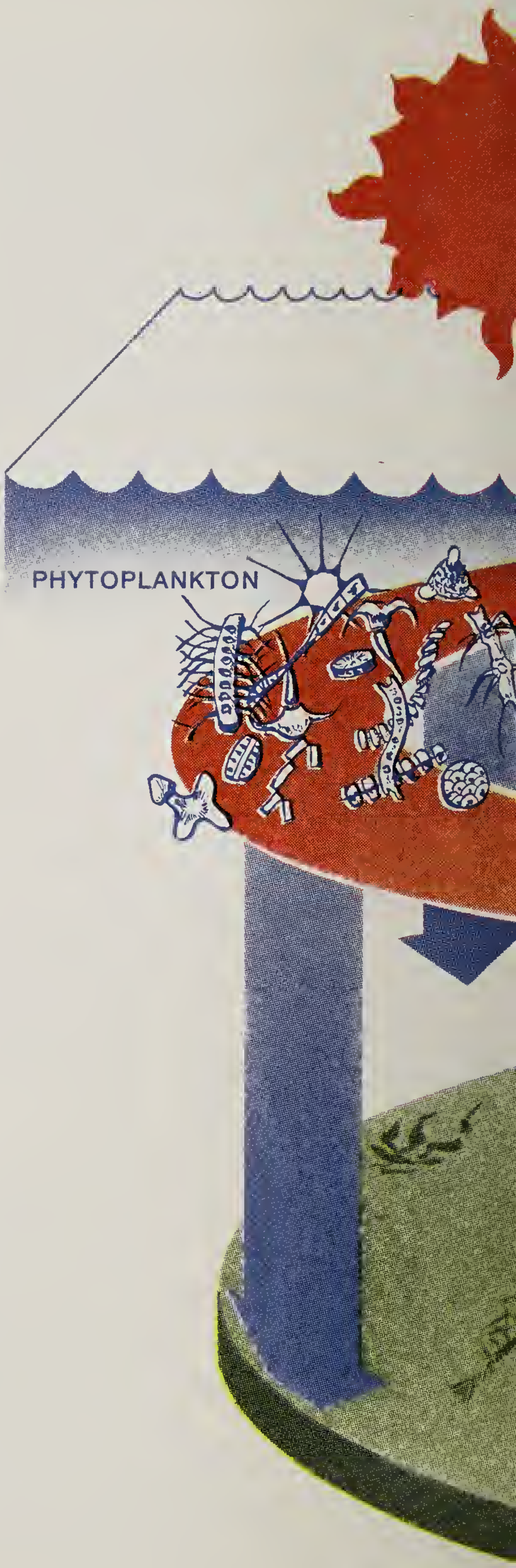
Photographs by Neil Swanberg

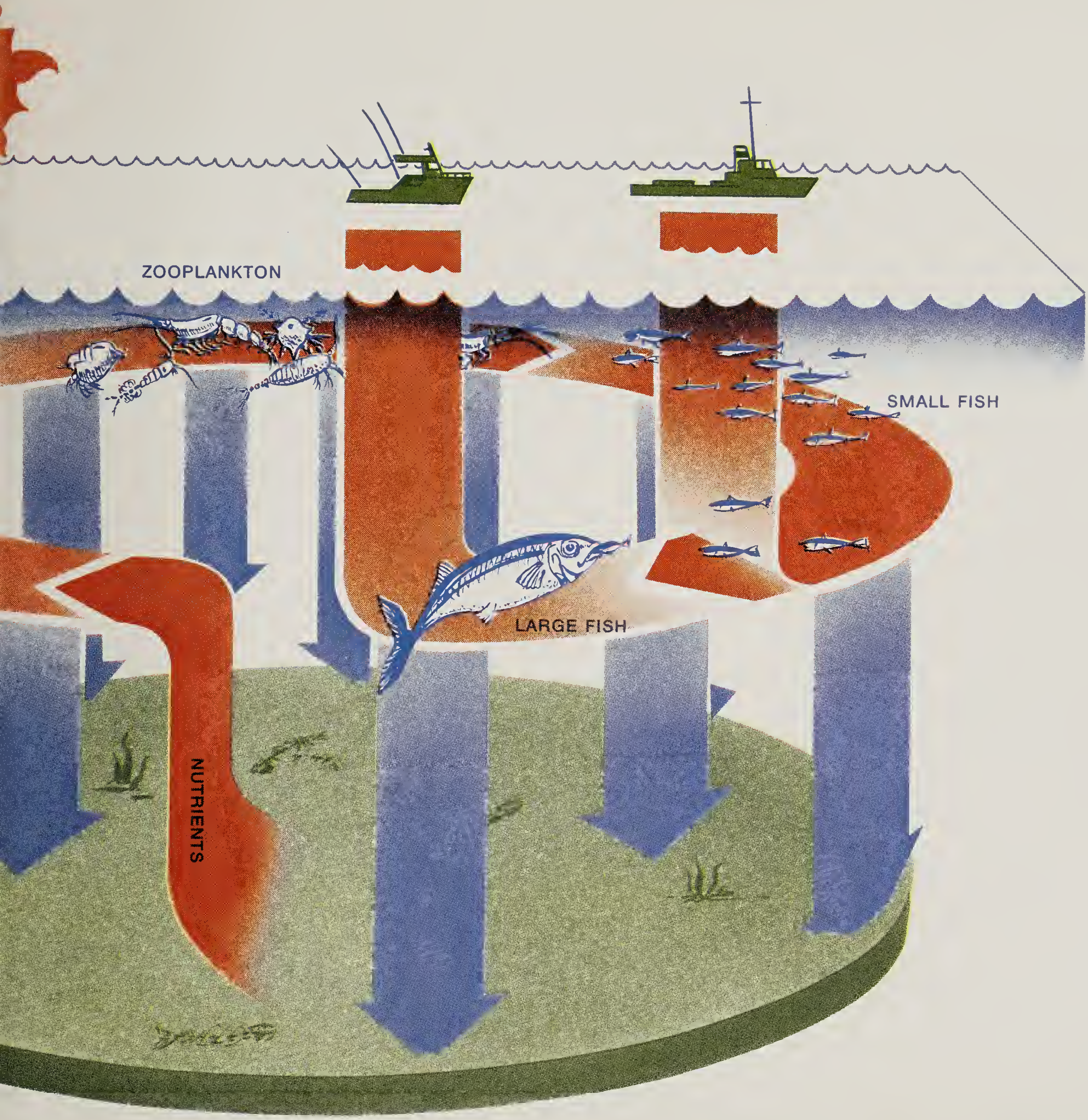
The zooplankton found in our oceans are tremendously diverse in size and shape. Some are microscopic, like the protozoans, while others are several feet across, like some jellyfish. They vary in color from transparent or white to gorgeous shades of scarlet and blue. Some live among the shallow reeds that grow in waters close to shore, while others live in the cold depths of the ocean. Some are only temporary plankton, such as the larval forms of barnacles, clams, corals, mussels, and shrimps. Others are planktonic their entire life and are therefore termed permanent plankton. Radiolaria, like those seen in the film, and Foraminifera are among the simplest of the zooplankton.

The most numerous zooplankter in the sea is the copepod. Ranging in size from a pinhead to a grain of rice, the 5,000 known species of copepods make up nearly 80 percent of all ocean animals. Ravenous eaters, copepods each day consume about one-half of their own weight in phytoplankton or zooplankton. And yet only about 10 percent of what they eat is converted into flesh. Because the rest is given off as waste or energy, these animals must eat constantly in order to sustain themselves.

Eat and be eaten — ocean food chains: The myriad forms of life making up ocean food chains are interdependent — nothing is useless, and nothing is lost. Even those plants and animals that escape being eaten eventually die. They sink to the depths of the ocean, decomposing into inorganic nutrients necessary to phytoplankton in order to carry on photosynthesis. In this way, phytoplankton, the primary link in all ocean food chains, is replenished.

Generally, marine organisms feed on organisms somewhat smaller than themselves and, in turn, become a source of food for creatures that are somewhat larger. Each time an organism is eaten, about nine-tenths of its food value is lost to the next higher member of the chain. In long chains of perhaps four and five links, this results in a significant loss of energy, especially to those at the end of the chain. However, this energy is not ultimately lost; it is used to support other ocean food chains. Researchers have looked into the idea of harvesting highly nutritious zooplankton for direct human consumption. We would then be able to utilize energy from the oceans more efficiently.

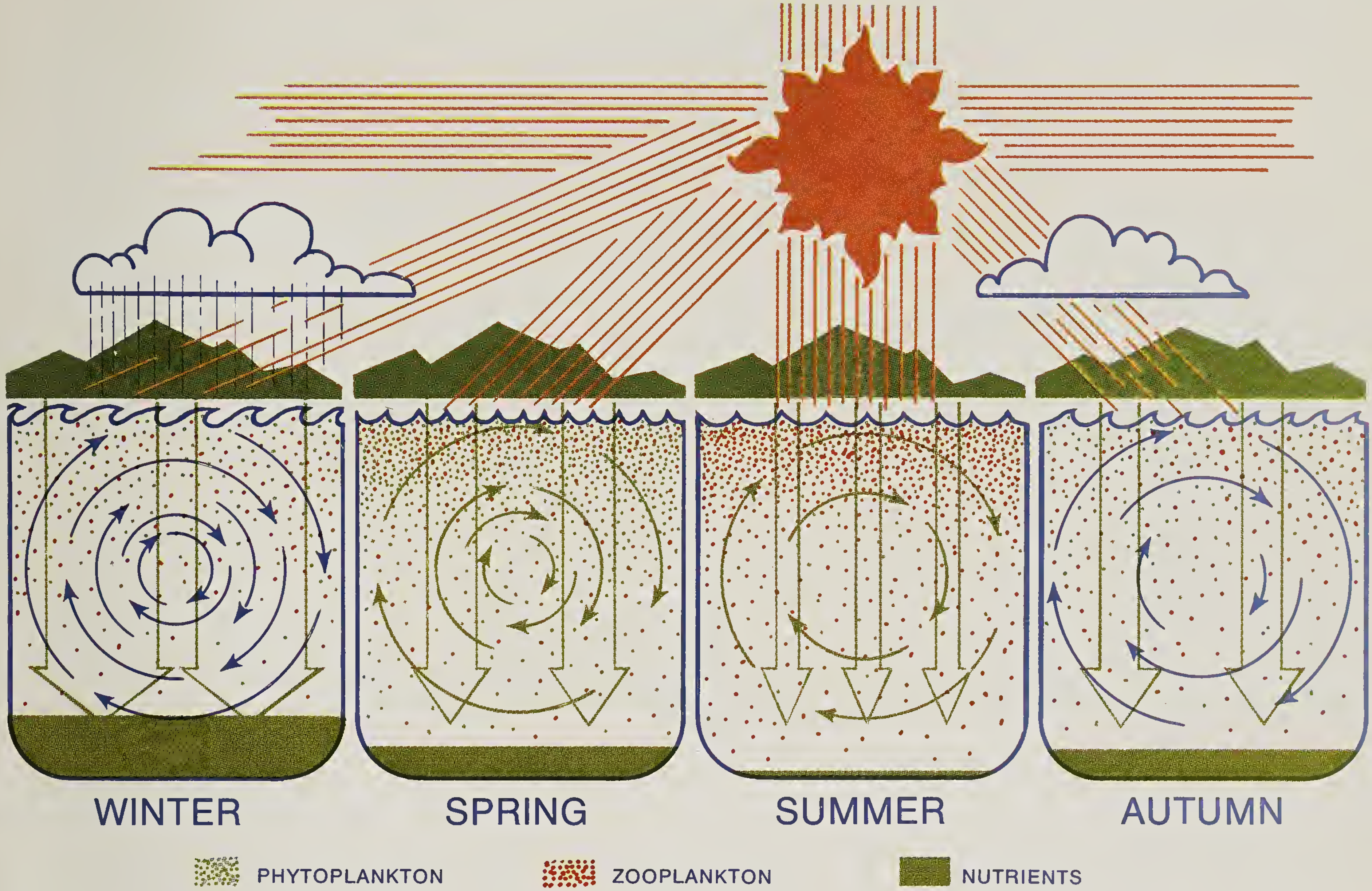


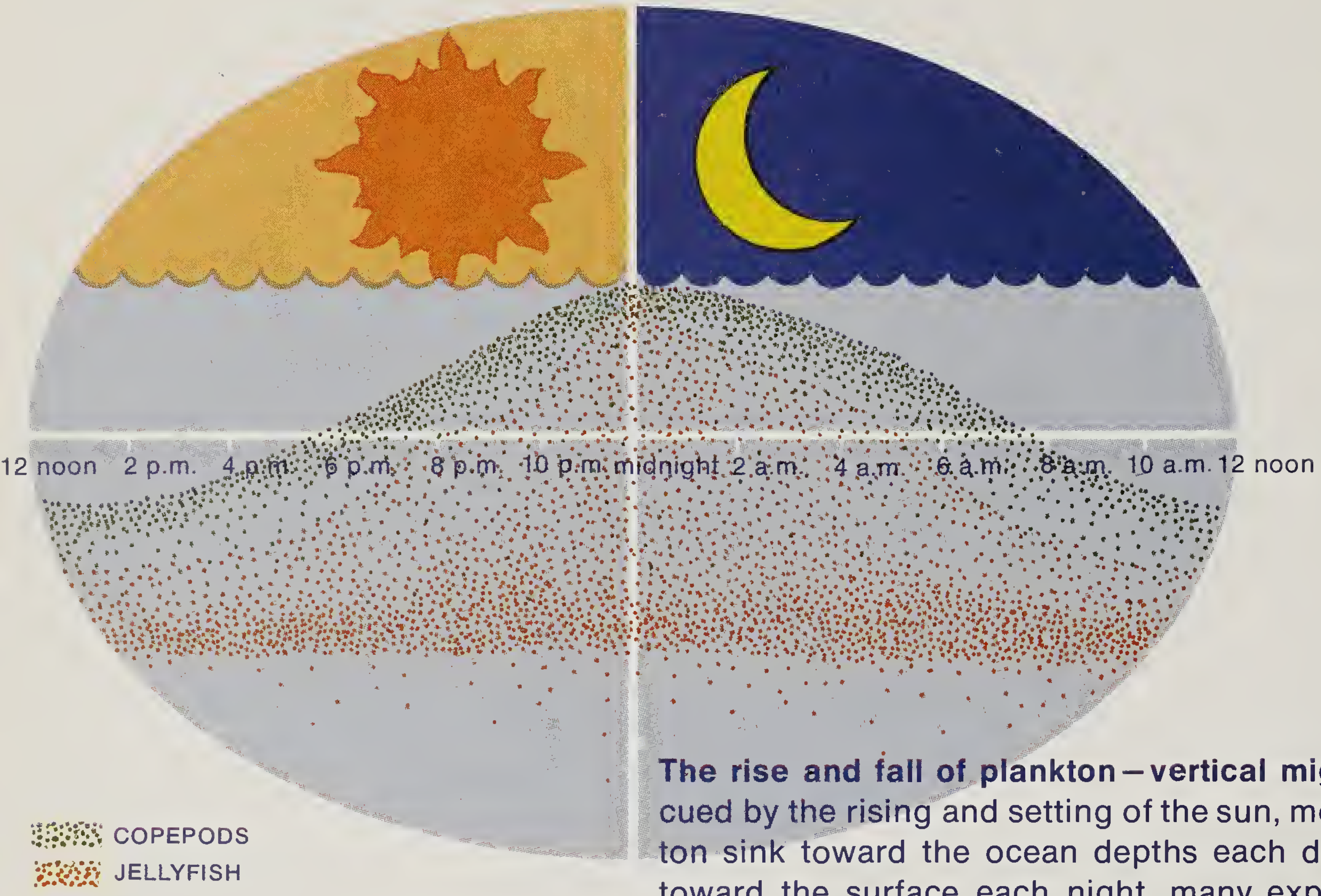

ZOOPLANKTON
SMALL FISH
LARGE FISH
NUTRIENTS

Summerfallwinterspring—seasonal cycles: Like plants on land, phytoplankton need sufficient water, sunlight, and mineral nutrients in order to grow. While water is always present, the availability of nutrient salts (phosphates and nitrates) and the intensity of the sunlight penetrating the ocean surface vary from season to season. Whatever the season, ocean conditions must be well-balanced for plant and animal plankton to thrive.

In high latitudes phytoplankton bloom in great numbers in spring. During this season conditions are particularly well-balanced: The sun is high and strong, and the ocean is rich in salts, due to the upwelling of nutrients caused by winter storms. These nutrients come from decayed matter in the ocean depths. By summer the sun is directly overhead, but phytoplankton have depleted the waters of nutrient salts. The animal plankton population, grazing ravenously on the rich supply of plant plankton, reaches a peak in late summer and reduces the number of phytoplankton at the ocean surface.

The quantity of phytoplankton remains low until the phosphates and nitrates in the water are replenished. This happens as autumn storms once again churn up the necessary salts from the ocean depths. For a brief time only, there is a second, smaller burst of plant life. Then in late fall, because sunlight is weak, plant populations and, consequently, animal populations decline to their low winter levels. Winter is the time when the elements that will sustain the life cycles just described are replenished.


WINTER
SPRING
SUMMER
AUTUMN
PHYTOPLANKTON
ZOOPLANKTON
NUTRIENTS

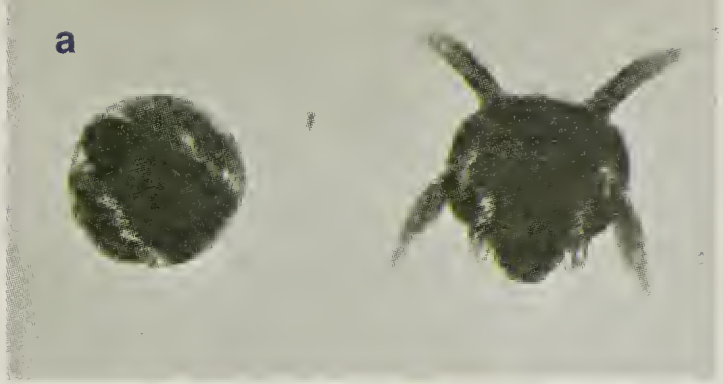


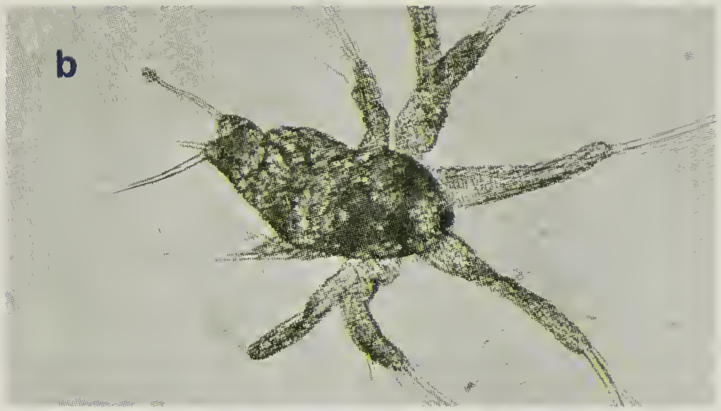
The rise and fall of plankton—vertical migration: As if cued by the rising and setting of the sun, most zooplankton sink toward the ocean depths each day and move toward the surface each night, many expending great amounts of energy in the process. Phytoplankton, dependent on sunlight, do not move far from the ocean surface. Scientists still are not certain why zooplankton make their daily journey, although much research has been done on this phenomenon. Some believe that vertical migration is zooplankton's way of getting from one feeding ground to another. Others think that this vertical migration is a way of counteracting the drift of ocean currents. Whatever the explanation, light surely plays a major role, because the migration seems to be synchronized with the rising and setting of the sun.

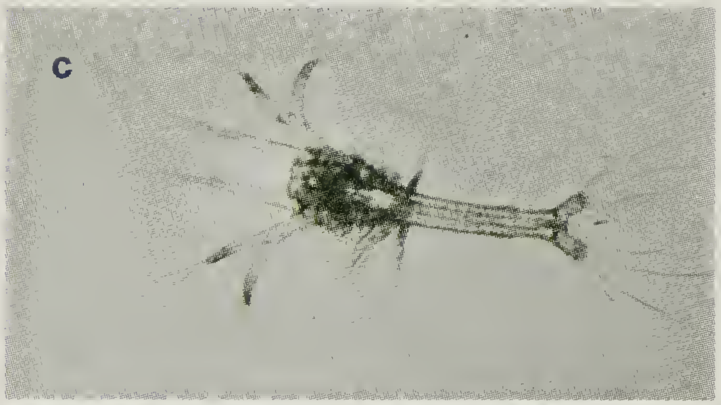
Plankton temporarily: Many of the juvenile forms of invertebrates, including the crustaceans, are radically different from their adult forms. In fact, many larval forms were once considered to be separate species and were named accordingly. It is now known that barnacles, crabs, mussels, shrimp, some starfish, and certain other invertebrates pass through larval stages during which they belong to the plankton community. Drifting along with ocean currents, these temporary zooplankton feed on phytoplankton and are themselves consumed by larger creatures in the ocean's food chains.

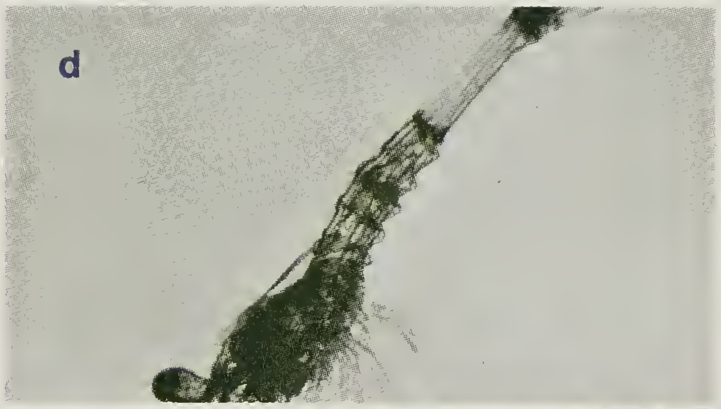
Upon hatching, most larval forms are small and light. Barnacles, as seen in the film, hatch as very small larvae called nauplius larvae. These have a single eye in the middle of their head, three pairs of swimming legs to keep the growing form from sinking to the bottom of the ocean, and a forked tail. In a more advanced stage they are called cyprid larvae. Most crab eggs hatch into larvae called zoea larvae, which have three pairs of bristly legs, a pair of developed eyes, a forked tail, and long spines that aid in floating. The crab larvae pass through another stage called megalops before becoming adults.

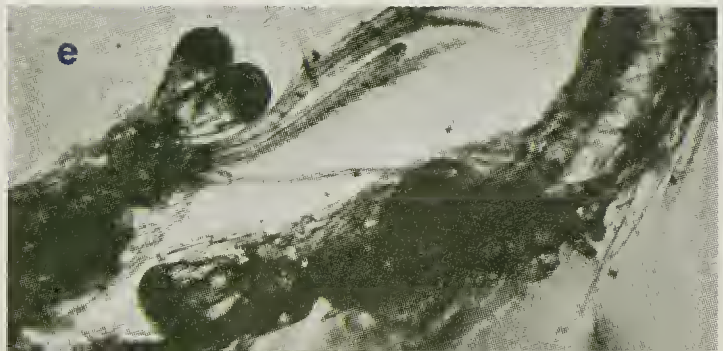
The photographs show the developmental stages of the Japanese kuruma shrimp *(Penaeus japonicus).* Cousin to the Florida pink shrimp, the adult kuruma shrimp can grow as large as nine inches in length. Thirteen to fourteen hours after the adult female spawns, the eggs (**a**) hatch into the nauplius stage. Barely visible to the naked eye, these tiny creatures (**b**) swim by rapidly beating their appendages. For 36 hours they feed on the yolk of their eggs, to which they are still attached.











Photographs by James Pickerell

In the next stage, the protozoeal stage (**c**), planktonic shrimp can no longer rely on nutrition from their eggs. They are forced to seek out their own food, usually a dinner of diatoms. As the larvae grow so do their appetites. They change from the protozoeal to the zoeal stage (**d**). Finally, the shrimp larvae develop into the post-larval stages (**e**); soon after they become adults (**f**)—much to the delight of discriminating diners.

Suggested Activities

Equipment for collecting: The first thing students will need is a plankton net. Small, inexpensive nets can be purchased from a biological supply house (see Additional Resources) or made in class by students. If students make nets they should use nylon, cheesecloth, or silk for netting. First, have them shape the material into a cone, then wrap the wide end of the net around a strong wire frame, six to eight inches in diameter, and secure. To the tapered end of the net, have them tie a small jar (jars with threaded necks are best) for collecting specimens. If students wish to collect adult crustaceans or other adult invertebrates as well as their planktonic larval forms, they can purchase a 20′ seine net or a large, flat-bottom net. These invertebrates can be kept in a marine aquarium. Berrill's *The Life of the Ocean* (see Additional Resources) gives complete instructions for setting up an aquarium.

Collecting diatoms and data: If you go on a field trip to an ocean or a pond, be certain that students bring along enough jars for all the samples they plan to bring back to class. Have class members label each jar with detailed collection data (date, location, time, depth, etc.).

During the day and again several hours after sunset, students can collect specimens by towing a small, weighted net with a collecting jar attached through the water. Make certain that the collecting jar is full of water before each tow so that the jar will sink. This will ensure an adequate plankton sample. Have students collect samples from different locations: close to shore, offshore (if pier or boat is available), and among weeds. Each time students collect samples, they should take one sample by towing the net vertically, up through the water, and another by towing it horizontally, across the surface.

Young students in particular may become discouraged during this activity, because plankton are hard to see. Suggest that they hold the collecting jars up to the light —the larger plankton will then be visible. Plankton should be able to live in a laboratory for about one week if kept in a refrigerator with just a few specimens to a jar. Plan all lab activities within this one week limit.

Note: Students using seine or flat-bottom dip nets to collect large plankton, such as the larvae of crustacea, should be sure to bring back water from each collecting site with their plankton. Experimenters should try to keep the number of plankton per jar at a low level.

In the lab: Students will be fascinated by the creatures they have collected when they view them through microscopes having magnifications of at least 10x-50x. Students can prepare life histories of members from one sample or make comparative studies of one or two plankters from several samples. Some things students should look for: how form relates to function in terms of body size, body shape, and design of flotation devices; how

Oxford Scientific Films

Sea gooseberries and a siphonophore.

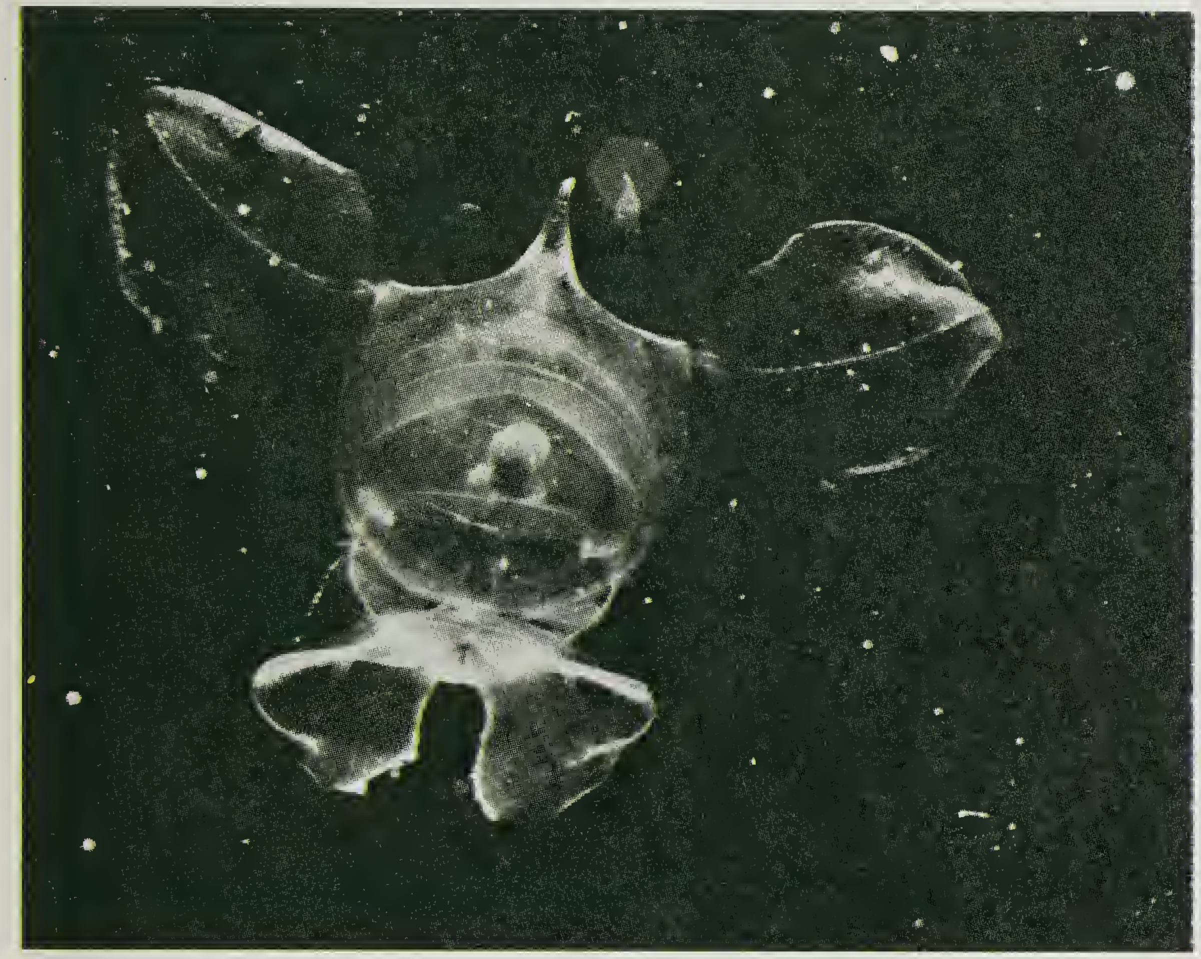
form changes in developmental stages; and how shape relates to habitat. Students can also use the plankton they have collected for future examination by preserving them in Formalin. Preserved plankton can be placed in a drop of glycerin on a slide for observation as needed.

Lunchtime: Have students try this simple, enjoyable experiment, which illustrates the concept of adaptation for survival. Students should place specimens of plankton under a microscope. Give students a pipette or eyedropper and tell them to imagine themselves hungry ocean creatures trying to catch some lunch. Students will have a difficult time catching certain types of plankton. Encourage them to draw conclusions about the relationship between size and mobility.

On the move: Zooplankton are highly **phototactic,** which means that they respond to light. In nature this is demonstrated by their daily vertical migration (see Key Points). In the lab, the same response can be seen in the following simple experiment. Have students place samples of zooplankton and water in an aquarium or long, deep dish. The students should then place a gooseneck lamp on either side of the tank. Turn off the room lights and pull the shades or curtains to darken the room. Have students turn on one of the lamps. Then have them turn it off and turn on the other lamp. Watch the plankton swarm. Have the class use the lamps to try to simulate the cycle of the sun.

Food for thought: The following simple activity will demonstrate just how ravenous zooplankton can be. **What students will need:** two 250ml Erlenmeyer flasks and one grow light (or they can use two incandescent lights and

R. W. Gilmer



A planktonic snail, the pteropod *Cavolinia tridentata*.

one fluorescent light). **From a biological supply house (see Additional Resources) order:** a culture medium; marine algae; sea salt; and 20-50 grazing zooplankters, copepods for example.

Students should mix the sea salt, marine algae, and culture medium and place equal amounts of the mixture in each flask. Then have them place the flasks under the grow light. After several days, each flask will start to turn green as the algae begin to bloom. At this point experimenters should add the zooplankters to one of the flasks and return both flasks to their positions under the grow light until the week is completed. What has happened?

Plankton in the news: In the early '70's swordfish and canned tuna were removed from grocery stores because they were contaminated with dangerous amounts of mercury. This happened as the result of the contamination of a long food chain, which began when plastic manufacturers dumped a harmless, inorganic form of mercury into our waters. Somehow bacteria transformed this harmless, inorganic form of mercury into methyl mercury, a deadly organic poison. Phytoplankton fed on the bacteria, zooplankton ate the phytoplankton, and so on up the food chain to the tuna and swordfish. Mercury contamination increased at each food transfer as larger and longer-lived predators consumed greater amounts of contaminated prey. This resulted in concentrations of the substance high enough to warrant the removal of tuna and swordfish from the market.

Encourage students to investigate the relationship between plankton and pollution. Other research topics might include: harvesting plankton for human consumption, plankton as oil producers, or plankton and whales. Good descriptions of eating plankton can be found in Thor Heyerdahl's *Kon Tiki: Across the Pacific by Raft* (Translated by F. H. Lyon. Chicago: Rand McNally, 1950).

For plankton devotees: Interested students might enjoy this long-term photography project. In May place a piece of plain wood on a pier where it will be splashed by the water. Over the summer barnacles similar to those in the film will begin to grow on the wood. If students take pictures at regularly scheduled intervals, their photo essays will show the growth of the barnacle population. The project would be even more interesting and revealing if pictures were taken both during the day and at night.

Additional Resources

Bibliography

Bardach, John. *Harvest of the Sea.* New York: Harper and Row, 1968. Optimistic and readable account of the harvesting of our oceans for plankton and other natural resources useful to humans.

Berrill, Norman J. *The Life of the Ocean.* Our Living World of Nature Series. New York: McGraw-Hill in cooperation with The World Book Encyclopedia, 1966. A clearly written text for young readers, providing a general look at life in the ocean. Devotes two chapters to plankton. Complete with diagrams and color photographs.

Gosner, Kenneth L. *Guide to Identification of Marine and Estuarine Invertebrates: Cape Hatteras to the Bay of Fundy.* New York: Wiley-Interscience, 1971. An in-depth reference book particularly helpful to students studying East Coast plankton. This book comes complete with drawings, systematic identification lists, and extensive references.

Hamner, William M. "Blue-Water Plankton: Ghosts of the Gulf Stream." *National Geographic* (October 1974): 530-45. A diving expedition studies plankton of the Gulf Stream. Spectacular photographs.

Hardy, Alister C. *The Open Sea: Its Natural History, The World of Plankton.* The New Naturalist. Boston: Houghton Mifflin, 1956. A well-written and well-illustrated nontechnical introduction to the study of plankton. Also discusses ocean currents and seasons in the sea. Good reference book.

Oxford Scientific Films

The Portuguese man-of-war *(Physalia)* is a notorious member of the plankton community.

Morholt, Evelyn, Paul F. Brandwein, and Alexander Joseph. *A Sourcebook for the Biological Sciences*. 2d ed. New York: Harcourt, 1966. Includes instructions for activities designed to increase students' understanding of plankton. Includes instructions for preserving and culturing a variety of marine specimens and for maintaining a marine aquarium.

Silverberg, Robert. *The World Within the Ocean Wave*. New York: Weybright and Talley, 1972. For youngsters. An easy-to-read book totally devoted to the study of plankton. Helpful bibliography.

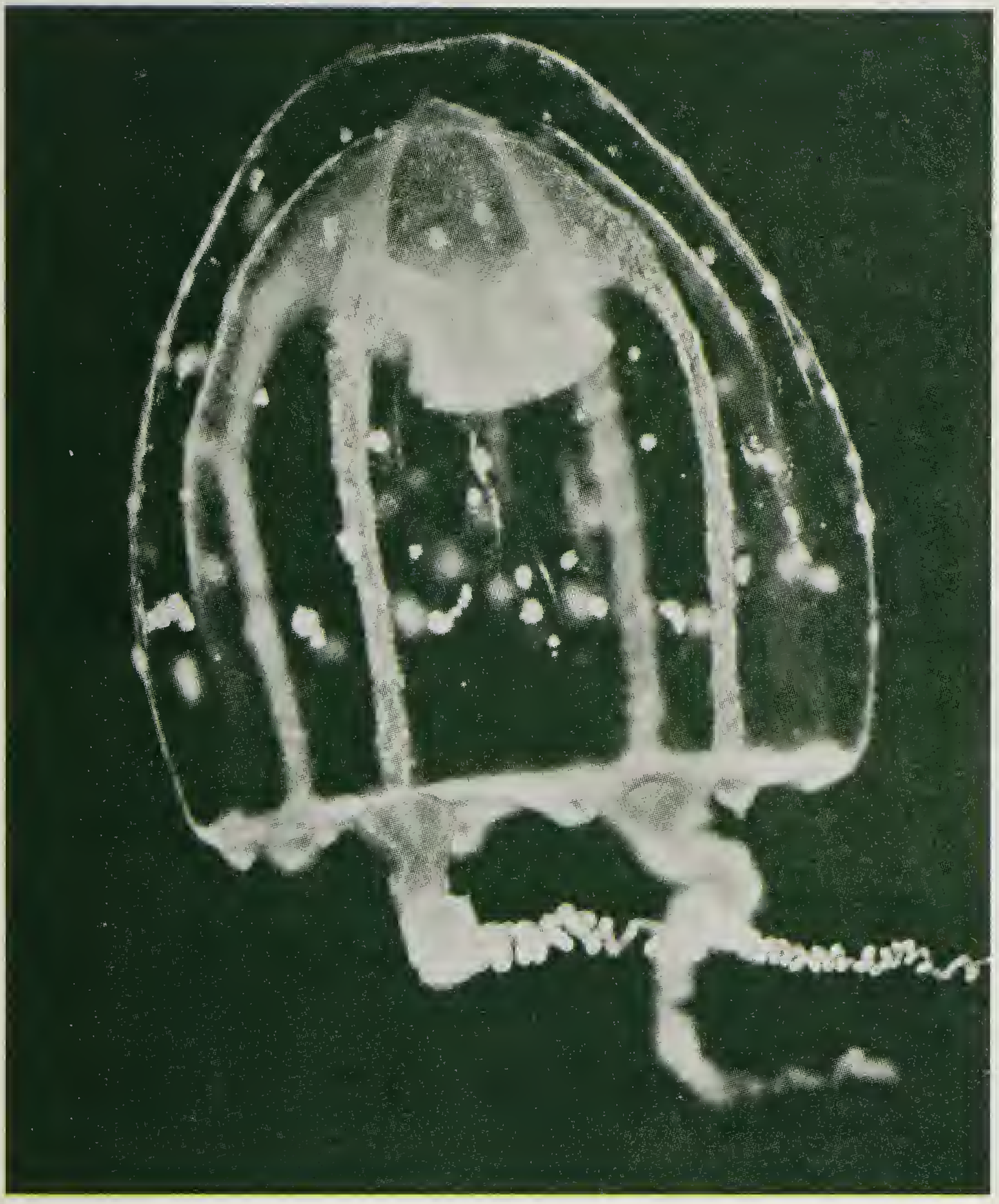
Ward, Ritchie R. "Life-giving Oils in the Strait of Georgia." *Natural History* (February 1974): 53-61. A fascinating, well-written study of the diatom-copepod-salmon fry food chain.

Zahl, Paul A. "How the Sun Gives Life to the Sea." *National Geographic* (February 1961): 199-225. Text and accompanying photographs describe the sun's influence on life cycles in the sea. Special attention given to several kinds of plankton.

Audiovisual and Lab-Material Suppliers

Fisher Scientific Co., Stansi Biology Div., Rt. 1, Box 47A, Clear Lake, Wis. 54005. Source for all lab supplies including live and preserved barnacles, sea gooseberries, diatoms, and jellyfish, and preserved Radiolaria. Will send preserved plankton samples from rivers, lakes, and oceans, from both clear and polluted waters. Also sells sea salts, one type of plankton net, and equipment for marine aquaria.

Oxford Scientific Films



An adult jellyfish.

Marine Biological Laboratory, Supply Dept., Woods Hole, Mass. 02543. Depending on the time of year, the live zooplankton "tow" may include the larvae of *Pennaria,* squid, lobster, butterfish and the adult stages of *Mnemiopsis* and *Aurelia*. Phytoplankton tow includes diatoms and dinoflagellates. Will also send seawater.

National Geographic Society, 17th and M Sts. N.W., Washington, D. C. 20036. Bio-Science Series includes a 16mm film and Teachers Guide entitled *Protists,* which discuss marine Radiolaria and Foraminifera.

Turtox/Cambosco, Macmillan Science Co., Inc., 8200 South Hoyne Ave., Chicago, Ill. 60620. Sells several kinds of plankton nets, sea salts, preserved plankton of the summer and winter, and a Water Faucet Plankton Gatherer. Also sells preserved slide specimens of diatoms, dinoflagellates, and radiolarians; live marine algae; and equipment for marine aquaria.

BIO-SCIENCE SERIES

05890	*Protists: Threshold of Life* (film unit)	$175
05896	*Protists: Threshold of Life* (videocassette unit)	$175
05061	*Protists: Threshold of Life* (teachers guide)	$1.25
05889	*Chick Embryology* (film unit)	$175
05895	*Chick Embryology* (videocassette unit)	$175
05058	*Chick Embryology* (teachers guide)	$1.25
05891	*Secret Life of a Trout River* (film unit)	$140
05897	*Secret Life of a Trout River* (videocassette unit)	$140
05064	*Secret Life of a Trout River* (teachers guide)	$1.25
05892	*Spiders: Aggression and Mating* (film unit)	$220
05898	*Spiders: Aggression and Mating* (videocassette unit)	$220
05067	*Spiders: Aggression and Mating* (teachers guide)	$1.25
05893	*Carnivorous Plants* (film unit)	$175
05899	*Carnivorous Plants* (videocassette unit)	$175
05070	*Carnivorous Plants* (teachers guide)	$1.25
*06005	*Life Cycle of the Honeybee* (film unit)	
*06006	*Life Cycle of the Honeybee* (videocassette unit)	
05160	*Life Cycle of the Honeybee* (teachers guide)	
*06003	*Pond-Life Food Web* (film unit)	
*06004	*Pond-Life Food Web* (videocassette unit)	
05157	*Pond-Life Food Web* (teachers guide)	
*06007	*Life Cycle of the Silk Moth* (film unit)	
*06008	*Life Cycle of the Silk Moth* (videocassette unit)	
05163	*Life Cycle of the Silk Moth* (teachers guide)	
06001	*Plankton* (film unit)	$175
06002	*Plankton* (videocassette unit)	$175
05154	*Plankton* (teachers guide)	$1.25

Fifteen or more teachers guides (titles may be mixed) available at $1.00 each.

*Please send inquiries for information and prices to National Geographic Society, Educational Services, 17th and M Streets N.W., Washington, D. C. 20036

DISCOUNT SCHEDULE

No. of films purchased	Discount
4	5%
5	6%
6	7%
7	8%
8	9%
9	10%

Plankton

A National Geographic Society educational presentation with film and collateral materials

From the worldwide resources of the
National Geographic Society

MELVIN M. PAYNE, President
MELVILLE BELL GROSVENOR, Editor-in-Chief and Board Chairman
GILBERT M. GROSVENOR, Editor

Collateral materials prepared by the
Television and Educational Films Division

DENNIS B. KANE, Chief
SIDNEY PLATT, Supervisor, Educational Projects
DONALD M. COOPER, Editor
ROCHELLE F. MOSKOWITZ, Curriculum Developer/Writer
LOUISE C. MILLIKAN, ELIZABETH S. WOOSTER, Researchers
ANNE B. KEISER, Picture Editor
YEORGOS N. LAMPATHAKIS, Art Director
BILL ALLAN, Graphic Artist

For the Film

Oxford Scientific Films Ltd.,
Oxford, England

GERALD H. THOMPSON, SEAN R. MORRIS, JOHN E. PALING, PETER D. PARKS, DAVID H. THOMPSON, JOHN A. L. COOKE, IAN G. MOAR, Directors

National Geographic Society

NICK NOXON, Writer
SIDNEY PLATT, Supervising Film Editor
LOUISE C. MILLIKAN, Researcher
CARL E. ZIEBE, Film Editor
LARY LEWMAN, Narrator

Consultants

J. DAVID ALLEN, Asst. Professor of Zoology, University of Maryland
THOMAS E. BOWMAN, Curator (Crustacea), National Museum of Natural History
THOMAS KINSEY, Teaching Fellow, University of Maryland
J. DAVID LOCKARD, Science Teaching Center, University of Maryland